

CLAIMS

1. A method for forming a semiconductor device comprising:

providing a semiconductor substrate;

5 forming a metal oxide layer over the semiconductor substrate;

forming a patterned gate electrode over a first portion of the metal oxide layer; and

10 removing a second portion of the metal oxide layer by heating the semiconductor substrate and flowing a halide-containing chemistry over the substrate while heating, wherein the second portion of the metal oxide layer is adjacent to the first portion of the metal oxide layer.

15 2. The method of claim 1, wherein the halide-containing chemistry further comprises hydrogen.

3. The method of claim 2, wherein the halide-containing chemistry is HCl.

4. The method of claim 1, wherein the metal oxide layer is hafnium oxide.

20 5. The method of claim 1, further comprising:

forming an patterned ARC layer over the patterned gate electrode prior to the flowing of the halide-containing chemistry; and

25 removing the patterned ARC layer after the flowing of the halide-containing chemistry.

6. The method of claim 5, further comprising:

forming a first interfacial oxide layer under the metal oxide layer;

removing at least a portion of the first interfacial oxide after removing the
second portion of the metal oxide layer;

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7. The method of claim 6, wherein removing at least a portion of the first
interfacial oxide layer is performed using a chemistry containing hydrogen and
fluorine.

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8. The method of claim 7, further comprising forming a second interfacial
oxide over the semiconductor substrate.

9. The method of claim 1, wherein the step of removing is further characterized
as being at a temperature of between about 625 degrees Celsius to 675 degrees
Celsius.

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10. The method of claim 9, wherein the step of removing is further
characterized as being at a pressure of about 50 torr for approximately 60
seconds and a flow rate of the halide-containing chemistry at about one SLM.

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11. The method of claim 1, wherein removing a second portion of the metal
oxide layer is performed in a reaction chamber in the absence of rf activation.

12. The method of claim 1, wherein heating is performed using a radiation
source.

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13. A method of removing a metal oxide layer that is over a semiconductor substrate, comprising:

placing the semiconductor substrate into a reaction chamber;

heating the metal oxide layer;

5 flowing a chlorine-containing chemistry while heating, wherein the chlorine-containing chemistry reacts with a portion of the metal oxide layer to create a byproduct, wherein the byproduct comprises an element from the metal oxide layer; and
removing the byproduct from the reaction chamber.

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14. A method for forming a semiconductor device comprising:

providing a semiconductor substrate;

forming a metal oxide layer over the semiconductor substrate comprising hafnium and oxygen;

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removing a portion of the metal oxide layer by heating the semiconductor substrate using radiation and flowing a chemistry containing hydrogen and chlorine.

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15. The method of claim 14, wherein heating the semiconductor substrate is at a temperature between about 625 degrees Celsius to 675 degrees Celsius.

16. The method of claim 14, wherein the semiconductor substrate comprises silicon.

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17. The method of claim 16, further comprising:

forming a first interfacial oxide layer under the metal oxide layer;

removing at least a portion of the first interfacial oxide after removing the portion of the metal oxide layer;

18. The method of claim 17, wherein removing at least a portion of the first interfacial oxide layer is performed using a chemistry containing hydrogen and fluorine.

19. The method of claim 18, further comprising forming a second interfacial oxide over the semiconductor substrate.

20. The method of claim 14, wherein removing a second portion of the metal oxide layer is performed in a reaction chamber in the absence of RF activation.

21. A method of forming a metal oxide comprising:

providing a semiconductor substrate;

forming a metal oxide layer over the semiconductor substrate;

removing a portion of the metal oxide layer by heating the semiconductor substrate and flowing a gaseous halide.

22. The method of claim 21, wherein the gaseous halide comprises hydrogen.

23. The method of claim 22, wherein the gaseous halide is HCl.

24. The method of claim 22, wherein the gaseous halide is HF.

25. The method of claim 21, wherein the metal oxide contains hafnium and oxygen.

26. The method of claim 21, wherein heating the semiconductor substrate is at
5 a temperature between about 625 degrees Celsius to 675 degrees Celsius.

27. A method of selectively removing a metal oxide layer from a
semiconductor substrate, wherein the metal oxide layer has an exposed portion
and a portion under a gate electrode comprising the step of flowing gaseous
10 HCl, in the absence of rf activation, over the substrate with the substrate heated
to between 600 and 800 degrees Celsius.

28. The method of claim 27, wherein the substrate is heated to between 625
and 675 degrees Celsius.
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29. The method of claim 28, wherein the metal oxide is hafnium oxide.

30. The method of claim 29, wherein the substrate is heated by radiation.

20 31. The method of claim 30, wherein the metal oxide overlies an oxide layer.